

# TILT CONTROL METHOD AND APPARATUS FOR OPTICAL DISC RECORDING AND PLAYBACK APPARATUS

## BACKGROUND OF THE INVENTION

### 5 1. Field of the Invention

The present invention relates to an optical disc recording and playback apparatus that is configured so that a signal is recorded to disc by a laser emitted from an optical pickup and the signal recorded on the disc is played back by  
10 the laser.

### 2. Description of the Related Art

Disc players for reading signals that have been recorded on discs using optical pickups have become pervasive. In  
15 addition to the playback function, disc recording and playback apparatuses configured so as to enable signals to be recorded onto discs by a laser emitted from an optical pickup have become commercialized.

In an optical disc recording and playback apparatus, it  
20 is necessary to accurately aim the laser beam emitted from the optical pickup to a signal track on the disc surface, hence focus control and tracking control operations are performed. The related focus control operation is performed by supplying driving current to a focusing coil for displacing an objective  
25 lens toward the disc surface, and the tracking control operation is performed by supplying driving current to a tracking coil for displacing the objective lens in a radial direction on the disc.

Recently, the trend has been to increase the signal density so as to record more signals onto a disc. To increase the density, it is necessary to optimally aim the laser beam onto the disc. To perform this operation, an operation for  
5 correcting the relative angle of deviation between the disc and the objective lens, namely, an optical pickup configured so as to allow a tilt adjustment has been developed. (As an example, refer to Japanese Patent Laid-Open Publication No. 2002-197698.) A technique for detecting the tilt of the  
10 optical pickup with respect to the disc and for adjusting the tilt has also been developed. (As an example, refer to Japanese Patent Laid-Open Publication No. 2001-52362.)

The technique described in Japanese Patent Laid-Open Publication No. 2001-52362 comprises a tilt sensor for  
15 detecting the tilt of an optical pickup with respect to a disc and is configured to perform a tilt adjustment operation on the basis of a signal obtained from the tilt sensor. Although this technique is capable of performing accurate tilt control, the tilt sensor is expensive. This results in a problem where  
20 the optical disc recording and playback apparatus becomes expensive.

Furthermore, the tilt adjustment coil that is built into the optical pickup is fixed to a support member for supporting the objective lens. However, deviations in its installed  
25 position as well as changes in the ambient temperature, changes in the position of and deterioration from aging of the optical disc recording and playback apparatus result in the tilt angle not being constant while a driving voltage is not

supplied to the tilt coil. Therefore, when the tilt adjustment operation is performed in this state, a problem arises in which an accurate tilt adjustment cannot be performed.

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#### SUMMARY OF THE INVENTION

The present invention writes an offset adjustment signal to a disc while modifying a driving signal level to a tilt control coil. Furthermore, the relationship between the driving signal level and the recording position at this time is stored.

An RF signal in the offset adjustment signal that was recorded on the disc is detected next. Then, a  $\beta$  value is detected from a positive peak level A1 and a negative peak level A2 of the RF signal using  $\beta = (A1+A2)/(A1-A2)$ . Then, the driving signal level of the tilt control coil corresponding to the maximum value of the beta value is detected to become an offset value for tilt control.

The offset value is determined in this manner, and tilt control is performed by adding this offset value to a tilt signal for performing tilt control, then supplying it to a tilt adjustment coil.

Thus, this minimizes the influence from deviation of the installed position of the tilt adjustment coil or from changes in temperature and deterioration from aging, thereby enabling accurate tilt adjustments to be performed.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a circuit block diagram of an optical disc recording and playback apparatus including a tilt control apparatus relating to an embodiment of the present invention.

5 Fig. 2 and Fig. 3 are waveform diagrams showing states of playback RF signals in the offset adjustment signals.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a circuit block diagram showing an embodiment  
10 of an optical disc recording and playback apparatus relating to the present invention and Figs. 2 and 3 are signal waveform diagrams illustrating an operation of the present invention.

In Fig. 1, a disc 1, which is mounted on a turntable (not shown) that is rotationally driven by a spindle motor (not shown), is rotationally driven by the rotation of the  
15 turntable, and is provided on the inner side with a test recording area for adjusting the laser output when performing recording operations.

Furthermore, the disc 1 has been recorded with  
20 positional information data as a groove called a pregroove. The signal recording and playback operations are performed on the basis of a wobble signal that is obtained from this pregroove. An optical pickup 2 comprising a built-in laser diode 3 for emitting light in the form of a laser beam, a  
25 monitor diode (not shown) for monitoring the light emitted from the laser diode, and a photo detector 4 for receiving the light beam that is reflected from the signal surface of the

disc 1, is configured so as to move in a radial direction on the disc 1 by a pickup feed motor (not shown).

Furthermore, the optical pickup 2 comprises a built-in focusing coil 5 for displacing an objective lens (not shown) toward the disc surface, a tracking coil 6 for displacing the objective lens in a radial direction on the disc 1, and a tilt adjustment coil 7 for adjusting the angle of the objective lens with respect to the disc 1.

A pickup control circuit 8 performs a focusing control operation for focusing the light beam from the optical pickup 2 onto the signal surface of the disc 1 on the basis of a signal obtained from the photo detector 4 that is built into the optical pickup 2 and a tracking control operation causing the light beam to track a signal track on the signal surface, and is configured so as to output a tracking control signal in accordance with a tracking error signal and a focusing control signal in accordance with a focus error signal.

A tracking coil driver circuit 9 inputs the tracking control signal that is output from the pickup control circuit 8 and is configured so as to supply a driving signal to the tracking coil 6 that is built into the optical pickup 2. A focusing coil driver circuit 10 inputs the focusing control signal that is output from the pickup control circuit 8 and is configured so as to supply a driving signal to the focusing coil 5 that is built into the optical pickup 2.

An RF signal amplifier circuit 11 inputs and amplifies an RF signal obtained from the photo detector 4 that is built into the optical pickup 2, and a  $\beta$  value detector circuit 12

detects the  $\beta$  value from the signal that is output from the RF signal amplifier circuit 11. Fig. 2 shows a waveform of playing back a signal that has been recorded on the disc 1. A1 and A2 are the positive peak level and the negative peak level of a high frequency signal, respectively.

Under these conditions, the  $\beta$  value is represented by  $\beta = (A1 + A2) / (A1 - A2)$ . When the  $\beta$  value is 0.04, for example, a specification is set where a signal is recorded at an optimum laser output. On the other hand, the relationship between the angle of the objective lens with respect to the signal surface of the disc 1, namely, the tilt, and the  $\beta$  value has a characteristic where the magnitude of the  $\beta$  value increases as the tilt adjustment improves.

This characteristic is described. In Fig. 2, P represents a pit that is formed by aiming laser light onto the disc 1 and a relationship with the playback waveform. Fig. 3 shows a state having an improved tilt adjustment compared to the state shown in Fig. 2. Since the laser light is efficiently aimed onto the signal surface of the disc 1, the shape of the pit P that is formed becomes larger when recording with the same laser output. As is clearly shown in the playback waveform diagram of Fig. 3, when the shape of the pit P becomes large, the positive peak level of the high frequency signal increases and the negative peak level decreases. An improvement in the tilt adjustment in this manner causes  $(A1 + A2)$  to increase and  $(A1 - A2)$  to decrease, thereby resulting in an increased  $\beta$  value.

A tilt control circuit 13 for inputting the  $\beta$  value that is detected and output by the  $\beta$  value detector circuit 12 and performing a tilt control operation on the basis of a tilt adjustment signal obtained from the driving signal that is output from the focusing coil driver circuit 10, and a tilt coil driver circuit 14 having its operation controlled according to the signal that is output from the tilt control circuit 13 are connected so as to supply a driving signal for tilt adjustment to the tilt adjustment coil 7 that is built into the optical pickup 2.

An offset detector circuit 15 enters an operating state during offset detection that is performed prior to the recording operation and is configured so that a control signal is output from the tilt control circuit 13 to the tilt coil driver circuit 14 to cause a driving signal for modifying the tilt in a stepwise manner to be output to the tilt coil 7. A memory circuit 16 stores the offset value detected by the offset detection operation to be described hereinafter and includes a function to output an offset signal to be added to the tilt adjustment signal obtained from the focusing coil driver circuit 10 when the tilt control operation is performed in the recording and playback operation states.

A laser driver circuit 17 for supplying a driving current to the laser diode 3 that is built into the optical pickup 2, and a signal recording circuit 18 for encoding the recording signal into a signal for recording and supplying it to the laser driver circuit 17 are configured so as to output the offset adjustment signal during offset detection.

The optical disc recording and playback apparatus relating to the present invention is configured as described above and its operation is described next. In a state where an ordinary recording operation or playback operation is being performed, a focus error signal and a tracking error signal are generated from the signal obtained from the photo detector 4 that is built into the optical pickup 2, and control operations for focusing control and tracking control are performed by the pickup control circuit 8 on the basis of the error signals.

When the control operations are performed for the various operations by the pickup control circuit 8, control signals are output from the pickup control circuit 8 to the focusing coil driver circuit 10 and the tracking coil driver circuit 9. As a result, driving currents are supplied from the focusing coil driver circuit 10 and the tracking coil driver circuit 9 to the focusing coil 5 and the tracking coil 6. These operations enable the light beam emitted from the optical pickup 2 to be focused onto the signal surface of the disc 1 by the focusing control operation and to track the signal tracks by the tracking control operation.

The focusing control operation and the tracking control operation by the pickup control circuit 8 are performed as described above. The tilt control method, a major idea of the present invention, is described next.

In the optical disc recording and playback apparatus relating to the present embodiment, an operation is performed to set an offset value required for accurately performing the



tilt control operation prior to performing the recording operation. In this setting operation, a signal for performing the operation to set the offset value is first output from the offset detector circuit 15 to the tilt control circuit 13.

5        In accordance with this signal, the tilt control circuit 13 records an offset adjustment signal in the test recording area on the disc 1. In this operation, in a state where the normal tilt control operation is not performed (state where the normal tilt control signal = 0), a control operation is  
10 performed so that a signal for modifying the tilt angle a step at a time is output in a stepwise manner from the tilt coil driver circuit 14 to the tilt coil 7. It is preferable to set the modification range slightly larger than the estimated range in which offsets are likely to occur. Furthermore,  
15 although it is preferable to perform the modification in steps, it may also be performed continuously.

First, when the control signal is output from the tilt control circuit 13, a driving signal is supplied from the tilt coil driver circuit 14 to the tilt adjustment coil 7 so as to  
20 modify the tilt of the objective lens in one direction by one step. As a result, the objective lens is tilted by one step in the direction of the tilt adjustment by the driving operation of the tilt adjustment coil 7. The tilt control circuit 13 sequentially outputs control signals according to a  
25 predetermined method, and as a result, the tilt of the objective lens is sequentially modified within a predetermined range.

During the operation for offset detection, an operation is performed to modify the tilt of the objective lens one step at a time by the signal that is output from the offset detector circuit 15. This operation is performed while

5 recording the offset adjustment signal in the test recording area that is provided on the inner side of the disc 1.

Namely, the offset adjustment signal is output from the signal recording circuit 18 to the laser driver circuit 17, and the signal is recorded in the test recording area of the disc 1 by

10 the laser beam that is output from the laser diode 3. When this recording operation is performed, the relationship between the recording position and the level of the signal that is output from the offset signal detector circuit 15 is stored, such as into the memory circuit 16. Namely, by  
15 sequentially modifying the tilt of the objective lens while emitting the laser beam, the offset adjustment signal is written to the test recording area and the relationship between the recording position and the tilt of the objective lens is stored into the memory circuit 16.

20 After the completion of the operation to modify the tilt of the objective lens on the basis of the signal that is output from the offset detector circuit 15, an operation is performed to play back the offset adjustment signal that was recorded on the disc 1. This signal playback operation moves  
25 the position of the optical pickup 2 to the start position for the recording operation of the offset adjustment signal and is performed without the driving signal being supplied to the

tilt adjustment coil 7 and with the objective lens at a intermediate position.

When the playback operation is performed for the recorded offset adjustment signal while modifying the angle of the objective lens with respect to the disc 1, the level of the RF signal, which is obtained from the reflection off the disc 1, changes. The offset adjustment signal that was recorded in the test recording area on the disc 1 is amplified by the RF signal amplifier circuit 11, and is then input by the  $\beta$  value detector circuit 12.

As the tilt of the optical pickup 2 with respect to the signal surface of the disc 1 is adjusted in the correct direction, the value of A1 obtained from the RF signal increases and the value of A2 decreases. Thus, when the signal, which was recorded while the angle of the tilt was modified in steps, is played back, the  $\beta$  value reaches a maximum then decreases.

When the offset adjustment signal is recorded while the objective lens is tilted in steps in the direction of the tilt adjustment by the driving operation of the tilt adjustment coil 7, the  $\beta$  value obtained from the RF signal, which is the playback signal, changes. Thus, when the driving voltage is supplied to the tilt coil 7 at the recording position of the offset adjustment signal where the  $\beta$  value reaches a maximum, an operation is performed to store the value of the control signal, which is output from the tilt control circuit 13, into the memory circuit 16 as the offset value.

The offset value is stored into the memory circuit 16 as described above. The tilt adjustment operation is described next.

When the optical disc recording and playback apparatus  
5 is in the playback state or recording state, and the relationship between the optical pickup 2 and the disc 1 is in a state requiring tilt adjustment to be performed, the driving signal for modifying the tilt of the objective lens is supplied to the tilt adjustment coil 7. The tilt adjustment  
10 signal for modifying the tilt utilizes the driving signal that is supplied to the focusing coil 5. The driving signal that is supplied from the focusing coil driver circuit 10 to the focusing coil 5 is a DC voltage signal superimposed with an AC signal. Namely, the DC voltage is a signal for placing the  
15 objective lens at an operating position and the AC signal is for displacing the objective lens by tracking the fast movements of the disc 1. The above-mentioned DC voltage is for displacing the objective lens to an operating position in accordance with the positional relationship between the signal  
20 surface of the disc 1 and the optical pickup 2, and the tilt adjustment can be performed by utilizing the change in this DC voltage.

A change component of the DC voltage included in the driving signal that is output from the focusing coil driver  
25 circuit 10 to the focusing coil 5 is extracted as the tilt adjustment signal. To the extracted signal is added the offset value stored in the memory circuit 16, and this signal is supplied as a tilt control signal to the tilt coil driver

circuit 14. As a result of this operation, the driving signal for tilt adjustment is supplied from the tilt coil driver circuit 14 to the tilt adjustment coil 7 so that an operation to adjust the angle of the optical pickup 2 to an optimum  
5 state with respect to the disc 1, namely, the tilt adjustment operation, is accurately performed.

In the present embodiment, the tilt adjustment signal was obtained from the driving signal supplied to the focusing coil 5. However, an apparatus may also be configured so as to  
10 perform tilt adjustment by utilizing the changes in the level of the RF signal.

While there has been described what are at present considered to be preferred embodiments of the invention, it will be understood that various modifications may be made  
15 thereto, and it is intended that the appended claims cover all such modifications as fall within the true spirit and scope of the invention.